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AUTHOR Peister, W. A.
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ABSTRACT

This monograph presents an autoinstructional program in the physical sciences. It is considered useful at the higher, middle and lower high school levels. Three behavioral objectives are listed and a time allotment of 35-40 minutes is suggested. A bibliography is included. A script, incorporating the use of a cassette player and slides, is used by the student when attempting the six experiments in the packet. Student objectives, a set of review questions and a vocabulary sheet are part of the instructional packet. (EB)

CHARACTERISTICS OF TRANSVERSE AND LONGITUDINAL WAVES

Prepared By

W. A. Reister
Science Teacher
NEWARK SCHOOL DISTRICT

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TEACHER'S GUIDE

PACKET NUMBER	531.23 R
SUBJECT	Physical Science
TITLE	Characteristics of Transverse and Longitudinal Waves
LEVEL	Higher Middle and Lower High School
BEHAVIORAL OBJECTIVES	1. The student will demonstrate he can produce transverse and longitudinal waves. 2. The student will compare longitudinal and transverse waves. 3. The student will be able to define wave length, frequency, amplitude, node, compression, rarefaction, by answering the questions asked at the end.
EQUIPMENT	Cassette player and tape Slide viewer and 11 slides 20 to 30 foot rope Slinky or wire spring Piece of string
TIME	35 - 40 minutes
SPACE REQUIRED	Carrel and 20-30 linear feet
BIBLIOGRAPHY	<u>The Physical Sciences</u>, Fisk, Franklyn and Milo Blecha, Laidlaw Bros., Rene Forest, Illinois,1971. <u>Inquiry Into Physical Science</u>, Jacobson, Kleinman Heach, Carr and Sugarbaker; Von Postrand, N.Y., N.Y., 1969 <u>Focus on Physical Science</u>, Heimbs, Charles and John Price; Charles E. Merrill Pub. Co.,Columbus, Ohio, 1969

SCRIPT

PHYSICAL AND GENERAL SCIENCE
CHARACTERISTICS OF LONGITUDINAL AND TRANSVERSE WAVES

Have you ever been on the beach on a windy day? If so, you have probably seen waves traveling into the shore. How can the waves on the beach be described? You might say that the waves come into the shore in a regular pattern. One wave seems to be very much like another wave and the waves seem to be evenly spaced.

What is causing the waves? The waves that you see on the beach at a particular time are probably a certain height. But if you go to the beach on a day which is not as windy, the waves would not be as high. Why not? Evidently the moving air disturbs the surface of the water more on a windy day than on a calm day. Water waves are sometimes caused by some sort of disturbance in the air.

What causes waves which are produced in other substances? Can different kinds of waves be produced in the same substance? How do waves move from one place to another? These are some of the questions that you may have asked yourself. The study of waves and wave motion is complex. To begin we want to look at two types of waves; the transverse and the longitudinal wave.

First, let us define a wave. Waves may be defined as rhythmic disturbances that transfer energy from point to point through space or through a medium. Let us limit our definition of a wave as it applies only through a medium. If we do this, there are two main points to remember. One is that a wave is a disturbance in a medium and two, a wave transfers energy from one place to another. Medium used here refers to some form of matter. The rhythmic disturbances refer to any portion of the medium that has been forced out of its normal position as energy is being transferred through the medium.

One of the best ways to study the characteristics of waves is to experiment. You will be using simple tools; a rope, a Slinky, and some string.

Please turn to SLIDE #1. Moving a rope up once and down once from its rest position produces a single wave. If you move the rope up and down at regular intervals, you will have a continuous train of waves along the rope as shown in SLIDE #2. Look at SLIDE #2. You may go and do experiment number 1 on your sheet after turning off the tape recorder.

The source of the continuous waves in the rope is the rhythmic disturbance you caused by displacing the end of the rope. The rope used is the medium through which the waves travelled. Please turn to SLIDE #3. When the particles of the medium, or rope in this case, move at right angles to the direction of waves, the wave is a transverse wave. Note again that in a transverse wave particles of matter vibrate at right angles to the direction in which the wave travels. Look at the transverse wave as shown in SLIDE #3. Notice there are two places where the rope is displaced most from its rest position. This displacement upward from rest position is a crest. The displacement downward from its rest position is a trough. You can now go and perform experiment number 2 after turning off the tape recorder.

You have established that waves on a rope are transverse waves. Since the rope is a solid, it will resist a change in its shape. Transverse waves can travel only in a medium that resists a change in shape. Only solids resist a change in shape, liquids and gases do not. Liquids and gases will take on the shape of their containers.

Please turn to SLIDE #4. Here you see more characteristics of a wave. Every wave has a wave length. Wave length is the distance of one complete wave. A complete wave consists of a crest and a trough or a trough and a crest. Wave length is the distance from any point on a wave to the corresponding point on the next wave. Wave length can be measured as the distance from the beginning to the end of the wave. It can be measured as the distance from crest to crest or from trough to trough. Another characteristic of a wave can be seen on SLIDE #4 which you are viewing. That is amplitude. Amplitude is the distance from its rest position to a crest or to a trough. Amplitude is dependent on the energy of the wave. You can increase the amplitude of the wave produced on the rope by yanking the rope further from its rest position.

Please turn to SLIDE #5. Frequency is another characteristic of a wave. Frequency is the number of waves that pass a given point on the medium in a certain time interval. The period is the time it takes for one wave to pass a given point. For example, if it takes one wave 1/4 second to pass a point on your rope, 4 waves will pass the point in one second. Study SLIDE #5 to see the relationship.

Now turn to SLIDE #6. This slide shows how a wave is reflected. Observe that the reflected pulse is upside down. Compare the incident pulse with the reflected pulse. Please do experiment number 3 after you shut off the tape recorder.

We now want to discuss the idea of interference. When two waves on a rope meet, they interact to produce a distortion of the rope different from either wave. The interaction of waves in the same medium is called interference. Please turn to SLIDE #7. Interference can be constructive or destructive. Constructive interference occurs when two waves reinforce each other to produce a displacement greater than that of either wave. The amplitude of such waves will be the sum of the amplitudes of the interacting waves. Study your slide for a moment. When waves that are out of phase with each other interact, their amplitude subtract. This is destructive interference. Waves which are out of phase with each other may cancel each other out completely at the instant they meet.

Now please turn to SLIDE #8. When wave trains interact, a complex interference pattern called a standing wave is created. Find the point on SLIDE #8 where waves have cancelled each other. These points are called nodes - places where there is no displacement of the rope. Find the point where the waves have reinforced each the most. These points are called antinodes - places where there is a maximum displacement of the rope. Study SLIDE #8 for a few moments. Shut off the recorder and perform experiment number four.

You now want to use a Slinky or string for your next experimental situation. With the use of the Slinky, you will distinquish another kind of a wave. Please stop the recorder while you do experiment number 5.

Now please turn to SLIDE #9. The area where coils are closer together is a condensation or compression. The area where coils are farther apart is a rarefaction. One condensation and one rarefaction, or one rarefaction and one condensation together make up a complete wave.

Moving the end of the Slinky back and forth will produce a continuous train of waves along the Slinky. Again, the source of waves is a rhythmic disturbance just as it was in the rope. You can classify the waves produced on the Slinky by examining the motion of one point. Please turn to SLIDE # 10. This back and forth motion is along the same line as the line in which the wave is moving. This kind of wave is a longitudinal wave. In a longitudinal wave, the particles move along the same line as the waves move. Study SLIDE # 10 for a few moments. Now go and do experiment number 6 after you turn off the recorder.

Longitudinal waves will travel in any medium that resists a change in volume. In the Slinky, some coils are compressed and others are spread apart. The compressed coils take up less space or volume than the expanded coils. This results in forces in the spring which tend to restore the original volume occupied by each coil. The forces that arise from a resistance to a change in volume cause the wave pulse to move along the Slinky.

Since solids, liquids and gases all resist a change in volume, longitudinal waves can travel in all forms of matter.

Now, please turn to SLIDE #11. The terms used to describe transverse waves also apply to longitudinal waves and have the same meaning. Wave length is still defined as the distance from some point on a wave to the same point on the next wave, or as the length of a complete wave from one compression to the next or from one rarefaction to the next.

SLIDE #11 shows one way to measure wave length. From the middle of a compression to the middle of the next compression, or from the middle of a rarefaction to the middle of the next rarefaction.

Frequency is still defined as the number of waves that pass a point in a certain time interval, say a second.

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CHARACTERISTICS OF LONGITUDINAL AND TRANSVERSE WAVES

The amplitude is the greatest distance that a particle moves from its rest position. In the Slinky, the particle is one turn of the wave. The amplitude can be measured as the distance forward or backward from the rest position. Study SLIDE #11 for a few moments.

When longitudinal waves meet, interference patterns are set up. When the waves interfere constructively, they reinforce each other and the amplitude is increased. When the waves interfere destructively, the amplitude is reduced.

You have completed the procedures for the characteristics of both longitudinal and transverse waves. Answer the questions at the end of your sheet. If you need assistance, go back to the tape and slides or see your instructor.

STUDENT GUIDE

EXPERIMENT #1

Tie one end of a 20 - 30 ft. length of rope to a doorknob or other support. Holding the other end of the rope, stretch the rope so that it does not touch the floor. Now quickly yank your end up about one foot and back to the rope's original position. Observe how the distortion caused at your end of the rope travels to the other end. This distortion is called a wave pulse.

This time yank the rope down and back to its original position and bserve the downward pulse along the rope. Now quickly yank the rope up and back and down and back. Make a diagram of the pulses you have produced and label the pulses. The distortion produced from moving the rope up and back and down and back is a complete wave.

Now, go back to the carrel and continue on with the tape.

STUDENT GUIDE

EXPERIMENT #2

You can examine the motion at one point along the rope by tying a piece of string to the rope. After tying the string, attach one end of the rope to a doorknob. After pulling the slack out of the rope, quickly jerk the end of the rope you are holding up about one foot from its original position and back to its original position. Observe the way in which the piece of string moves as compared to the direction in which the wave is traveling. Sketch your observations and label the pulses and show the direction the wave and string are moving. As the waves move along the rope, the string moves up and down, or at right angles to the direction in which the wave is moving. This is a characteristic of a transverse wave.

After you have satisfied yourself with the experiment, go back to the carrel and continue on with the tape.

STUDENT GUIDE

EXPERIMENT #3

Tie one end of the rope to a doorknob. Start a wave pulse by moving the end you are holding up quickly, then back to its rest position. Observe the pulse as it arrives at the end of the rope where it is tied to the doorknob. Do this several times until you have been satisfied you have seen the reflected pulse as compared to the incident pulse. Sketch your observation and label the incident and reflected pulses.

Now go back to the carrel and continue on with the tape.

STUDENT GUIDE

EXPERIMENT #4

You must have a partner for the first part of this experiment.

You and a partner hold each end of the rope. Move each end of the rope up and back quickly at a given signal from your partner. Try this several times. Sketch your observation.

Now move one end of the rope up and back and the other end down and back at a given signal. This produces pulses which are out of phase. Note what happens as the waves meet and what happens as the waves pass each other. Sketch your observations.

Now examine what happens when you produce wave trains that interact. Tie one end of the rope to the doorknob. Move the end of the rope up and down at a constant rate to produce a wave train of an equal frequency. When the waves reach the doorknob, they are reflected but meet new incident waves on the way back. Do this several times and observe. Sketch your observations.

Now go back to the carrel and continue on with the tape.

STUDENT GUIDE

EXPERIMENT #5

Attach one end of the Slinky to a doorknob. Stretch the Slinky until it is fairly straight. Move the free end quickly toward the doorknob and back to its stretched position. Observe how the distortion produced, travels down the Slinky. The distortion is a region of the Slinky where the coils are closer together than elsewhere. This is a compression.

Now move the free end of the Slinky quickly away from the doorknob and back to its original stretched position. The distortion is a region where the coils are farther apart as it travels down the Slinky. This is a rarefaction.

Now move the free end of the Slinky toward the doorknob, back to its stretched position, away from the doorknob and back to its original stretched position. Do this quickly. Observe the distortions produced. An area where the coils are compressed, followed by an area where the coils are farther apart, moves along the Slinky. Sketch your observations and label the areas of compression and rarefaction.

Now go back to the carrel and continue on with the tape.

STUDENT GUIDE

EXPERIMENT #6

Tie a piece of string on the Slinky as you did with the rope. The Slinky is the medium for the wave to travel and the string represents a particle of the medium. Make a wave along the Slinky by moving the free end of the Slinky quickly away from the doorknob, back to its original stretched position and then toward the doorknob and back to its original stretched position. As the wave passes through the part of the spring where the string is tied, observe the motion of the string. The string moves back and forth - toward the doorknob and back, away from the doorknob and back. This back and forth motion of the string is along the same line in which the wave is moving. This kind of a wave is a longitudinal wave. Sketch your observations and show the direction the wave and the string are moving in the Slinky.

Now go back to the carrel and continue on with the tape.

STUDENT GUIDE

Objectives and instructions for characteristics of transverse and longitudinal waves.

Objectives:

1. You will produce both longitudinal and transverse waves by doing experiments.
2. You will compare longitudinal and transverse waves by observing them in your experiments and by answering the questions at the end of the lesson.
3. You will define the following terms: frequency, wave length, amplitude, compression, rarefaction, node, antinode.

At any time you may stop the tape and replay any section.

You will need a pencil. Paper is provided in the carrel for diagrams you are to do. A list of questions will be found in the carrel to be answered at the end of the lesson. Rope, string and spring are in the carrel.

When you are ready, place the earphones on and begin the tape.

STUDENT GUIDE

REVIEW QUESTIONS

1. What substances can act as a medium for transverse waves?

2. What is the frequency of a wave?

3. Define wave length.

4. How is wave length measured?

5. Define amplitude.

6. What is the difference between compression and rarefaction?

7. What substances can transmit longitudinal waves?

8. What are nodes and antinodes?

9. How are longitudinal and transverse waves alike in their behavior?

10. How are longitudinal and transverse waves different in their behavior?

STUDENT GUIDE

VOCABULARY

Amplitude	The distance from rest position of a wave to a crest or a trough.
Condensation	An area where waves are compressed or closer together.
Constructive Interference	Two waves interacting in the same medium so as to reinforce each other to produce a displacement greater than that of either wave.
Crest	The displacement upward from rest position of a wave.
Destructive Interference	Two waves interacting in the same medium but out of phase with each other, thereby diminishing their amplitude.
Frequency	The number of waves that pass a given point in a certain time interval.
Interference	The interaction of waves in the same medium so that they tend to either reinforce or cancel each other.
Longitudinal wave	A wave produced by compression and expansion in the direction the wave is travelling.
Transverse wave	Vibrations which move at right angles to the direction the wave is travelling.
Trough	The displacement downward from rest position of a wave.
Wave length	The distance between corresponding points on two successive waves.
Rarefaction	An area where waves are stretched from normal position.